EFFECT OF VARIATION OF COMPRESSION
ON THE
EFFICIENCY & ECONOMY OF A GAS ENGINE

G. A. GRASSBY
A. G. HALL

ARMOUR INSTITUTE OF TECHNOLOGY

1909

621.4
G 76

Illinois Institute
of Technology
Libraries

AT 143
Grassby, G. A.,
The effect of variation of
compression on the

THE EFFECT OF VARIATION OF COMPRESSION ON THE EFFICIENCY AND ECONOMY OF A GAS ENGINE

A THESIS

PRESENTED BY

G. A. GRASSBY, Jr.
A. G. HALL

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN

MECHANICAL ENGINEERING

ILLINOIS INSTITUTE OF TECHNOLOGY
PAUL V. GALVIN LIBRARY
35 WEST 33RD STREET
CHICAGO, IL 60616

Accepted 6/1/09
- G. F. Gebhardt
Prof. Mech. Eng.

H. M. Raymond
Dean of Eng. Studies

S. A. Grassby, Jr.

A. G. Hall

INTRODUCTION

Ithas been a matter of discussion among engineers as to whether increasing the compression on a gas engine would increase the efficiency and economy or not, some saying that the increase of friction more than offsets the gain in efficiency while others maintain that there is a marked gain in economy. It was the idea of the writers that there was a point intermediate between these two views where the efficiency and economy both reached a mean maximum. The following series of tests were made with the object in view of determining this intermediate point for a Fairbanks-Morse seven horse power engine when operating under certain given conditions.

OBJECT

It was the intention of the writers to increase the compression from its normal value of abbout 58 pounds to the limit as set by the strength of the head bolts, taking one hour runs on each compression, noting all the usual readings for a gas engine test. From the data thus obtained curves were to be drawn which would show how the efficiency and economy varied with the compression.

DESCRIPTION

The engine tested is a four stroke cycle single cylinder of the compression type. It is rated at seven horse power and has a bore of 6-3/4 inches and a stroke of 12 inches. A centrifugal governor acting on the "hit and miss" principle, controls the speed of the engine, maintaining an average of 254 R.P.M.

The ordinary poppet style is used for both the inlet and exhaust valves, the former being automatic and the latter mechanically operated by a cam driven by two to one gears from the main shaft. Ignition is secured by the use of an inclined cam on the large gear from which the motion is transmitted by a horizontal shaft to an oscillating lever which makes and breaks the circuit through platinum electrodes. The point of ignition may be varied through a considerable range by the adjustment of a screw on the tripping lever.

The power developed by the engine is absorbed by a form of Prony brake consisting of strips of wood held in place by iron straps. The load may be varied by adjusting a bolt between the ends of these straps,

thus changing the friction on a water cooled pulley. For obtaining the total power, a Crosby gas engine indicator was used with a 160 pound spring for the lower compressions and a 240 pound spring for the higher. The motion of the piston was communicated to the indicator by a properly adjusted pantograph and a cord. The explosions were recorded by a box counter made by Schaeffer and Budenburg, actuated by a lever connected to the exhaust rod.

The engine is so designed that the length of the connecting rod and consequently the compression in the cylinder, may be increased by inserting steel shims between the brass crank box and the end of the rod. A number of such shims were therefore made varying in thickness from .15 inch to .4 inch.

By the use of the proper combinations of these shims almost any desired compression could be secured. On examination, the cylinder was found to be worn and, instead of reboring it, a new piston was made, the end of which was turned down 1/16 inch for a length of 2-1/2 inches, thus permitting it to overtravel the unworn portion of the cylinder.

METHOD

A number of preliminary runs were made to get the engine into good condition and to determine the proper mixture of gas and air for good performance. While these were in progress it was decided to keep the brake horse power constant throughout the tests, thus simulating a practical plant operating on a constant load. This procedure also eliminated one variable and made the results comparable without much reduction.

The temperature of the jacket water was kept as nearly constant as possible at about 154 degrees Fahrenheit throughout the tests.

The indicator springs were carefully calibrated by attaching the indicator to a Crosby gauge tester, the pressures being produced in the same way as in calibrating gauges. The calibrations were checked by a repetition of this process. A curve showing the variation from the true scale is given on page 34 for reference, only those points being included which were used in the calculations of the results.

DISCUSSION

The results of the tests are plotted on page 11 where the various items are indicated as ordinates and the compression as abscissae. They are also given in tabular form on page 12. From the standpoint of determining the law of variation of the economy and efficiency with the compression, the results are far from conclusive, there evidently being no law expressing such variation. This is the natural inference from these tests but it is the opinion of the writers that such a law exists and may be determined by a series of tests in which several variables, overlooked in this investigation, are eliminated.

Probably the most important of these variables is that of the point of ignition. In these tests, it was attempted to keep

this constant merely by the general appearance of the "firing line" on the indicator cards. On closer investigation, however, it was found that considerable variation in the point of ignition could exist without materially changing the general appearance of the card as may be seen by reference to the sample cards herewith. By a series of tests on this engine by Bradley, Garcelon, and Longnecker (Thesis A.I.T. 1900) the effect of such variation was determined and the conclusions drawn in their summary are "that the maximum efficiency always occurrs when the ignition is before the end of the stroke; that the nearer the engine is working to its rated capacity, the nearer the end of the stroke should ignition take place; That for very early and very late ignitions the efficiencies are not so much affected

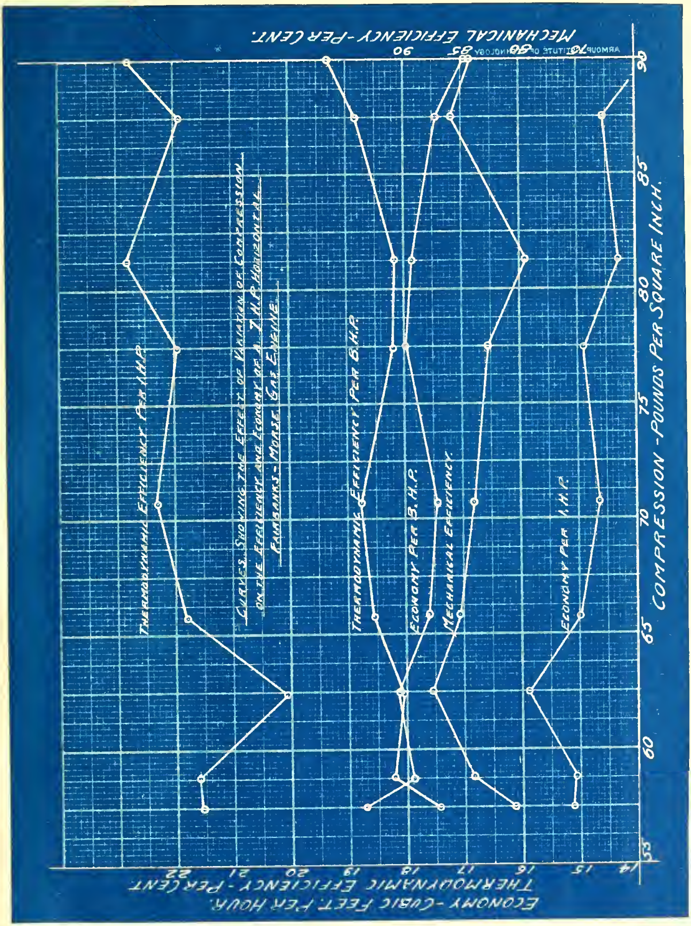
by a given change in the point of ignition as they are when such change is made in ignition nearer the end of the stroke."......

Also in a discussion by Prof.W.T.Magruder of a paper by Prof.C.V.Kerr in which were presented the results of these tests (A.S.M.E. Transactions Vol.22-Page 166) it was brought out "that the friction of a gas engine is not necessarily constant nor is it yet a function of the horse power; but rather that the friction increases with the earliness of ignition and that the maximum indicated horse power for a given brake horse power may be as much as 21 percent greater than the minimum."

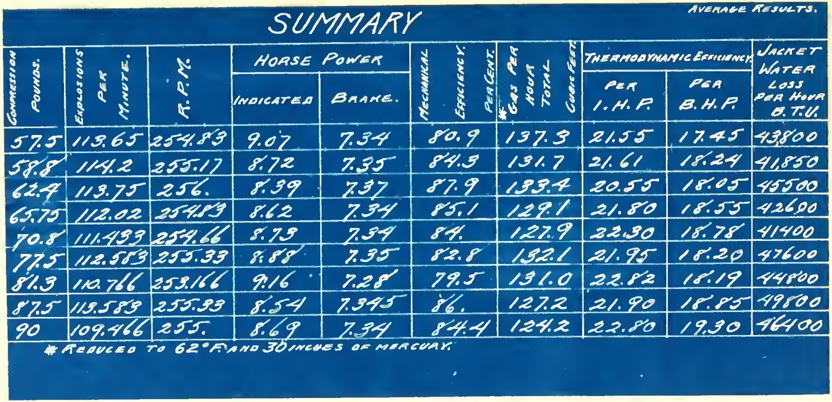
If these conclusions are correct, it would appear that, since in the present investigation, the ignition was very near the end of the stroke, a slight change in the time thereof would have the maximum effect

on the efficiency. From the curves accompanying Prof.Kerr's paper it was observed that a variation in the point of ignition of 1/2 inch before the end of the stroke to the end of the stroke would cause a decrease in the indicated horse power of about 1/4 horse power when the engine is developing 5 brake horse power. This corresponds to a difference of 5 per cent in the indicated horse power for the same developed horse power for this slight variation in the time of ignition.

With this in mind it would appear that the curves, presented herewith, could be corrected for the point of ignition by an application of the proper correction factor, so that they would represent some law governing the variation of the efficiency and economy with the compression.



CURVES SHOWING THE EFFECT OF VARIATION OF COMPRESSION ON THE EFFICIENCY AND ECONOMY OF A 7 H.P. HORIZONTAL FAIRBANKS-MORSE GAS ENGINE



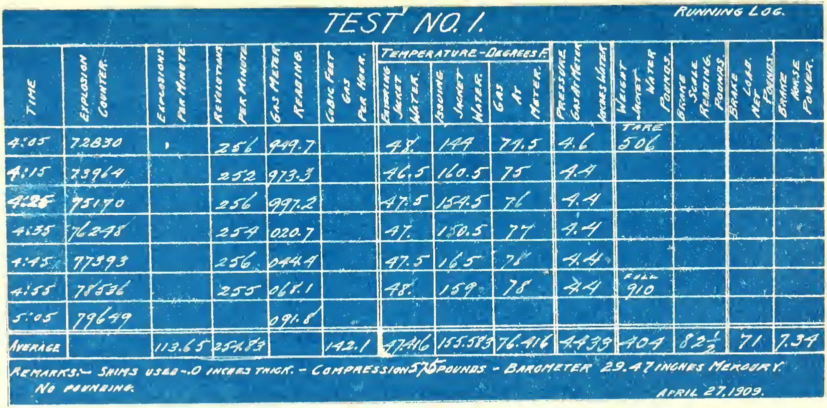
SUMMARY

AVERAGE RESULTS.

COMPRESSION POUNDS.	EXPLOSIONS PER MINUTE.	R.P.M.	HORSE POWER		MECHANICAL EFFICIENCY. PER CENT.	* GAS PER HOUR TOTAL CUBIC FEET.	THERMODYNAMIC EFFICIENCY		JACKET WATER LOSS PER HOUR B.T.U.
			INDICATED	BRAKE.			PER I.H.P.	PER B.H.P.	
57.5	113.65	254.83	9.07	7.34	80.9	137.3	21.55	17.45	43800
58.8	114.2	255.17	8.72	7.35	84.3	131.7	21.61	18.24	41,850
62.4	113.75	256.	8.39	7.37	87.9	133.4	20.55	18.05	45500
65.75	112.02	254.83	8.62	7.34	85.1	129.1	21.80	18.55	42600
70.8	111.433	254.66	8.73	7.34	84.	127.9	22.30	18.78	41400
77.5	112.583	255.33	8.88	7.35	82.8	132.1	21.95	18.20	47600
81.3	110.766	253.166	9.16	7.28	79.5	131.0	22.82	18.19	44800
87.5	113.583	255.33	8.54	7.345	86.	127.2	21.90	18.85	49800
90	109.466	255.	8.69	7.34	84.4	124.2	22.80	19.30	46400

* REDUCED TO 62° F. AND 30 INCHES OF MERCURY.

[illegible]
INSTITUTE OF TECHNOLOGY
[illegible]



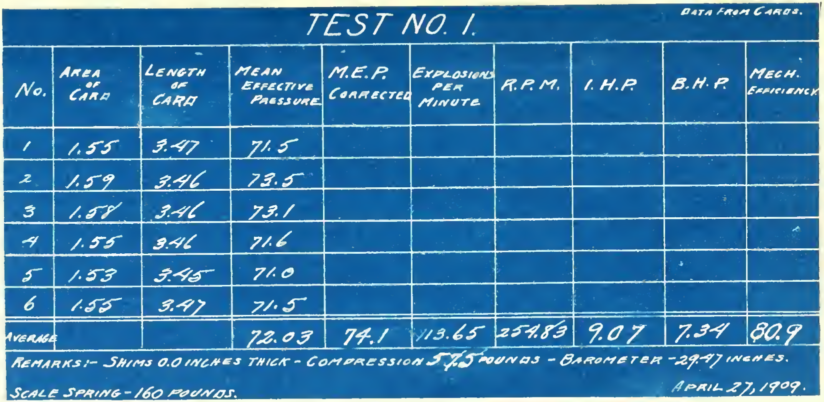
TEST NO. 1.

RUNNING LOG.

TIME	EXPLOSION COUNTER.	EXPLOSIONS PER MINUTE	REVOLUTIONS PER MINUTE	GAS METER READING.	CUBIC FEET GAS PER HOUR.	TEMPERATURE-DEGREES F. ENTERING JACKET WATER.	ISSUING JACKET WATER.	GAS AT METER.	PRESSURE GAS AT METER INCHES WATER	WEIGHT JACKET WATER POUNDS.	BRAKE SCALE READING. POUNDS.	BRAKE LOAD. NET POUNDS.	BRAKE HORSE POWER.
4:05	72830		256	949.7		48.	144	74.5	4.6	TARE 506			
4:15	73964		252	973.3		46.5	160.5	75	4.4				
4:25	75170		256	997.2		47.5	154.5	76	4.4				
4:35	76248		254	020.7		47.	150.5	77	4.4				
4:45	77393		256	044.4		47.5	165	78	4.4				
4:55	78536		255	068.1		48.	159	78	4.4	FULL 910			
5:05	79649			091.8									
AVERAGE		113.65	254.83		142.1	47.416	155.583	76.416	4.433	404	82½	71	7.34

REMARKS:— SHIMS USED—.0 INCHES THICK. – COMPRESSION 575 POUNDS – BAROMETER 29.47 INCHES MERCURY.
NO POUNDING.

APRIL 27, 1909.



DATA FROM CARDS.

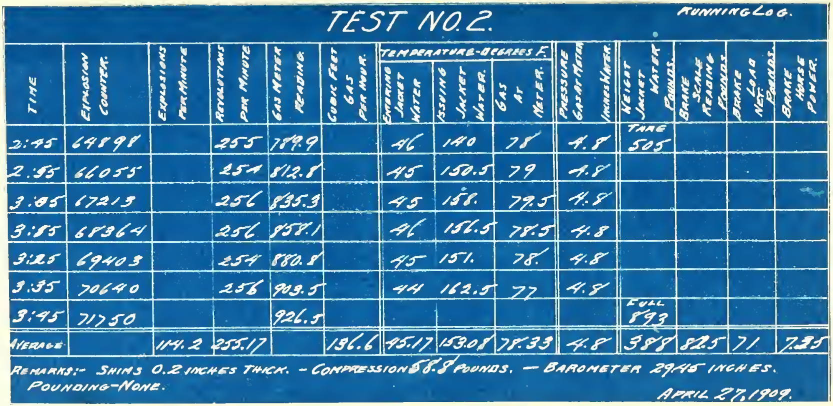
TEST NO. 1.

No.	Area of Card	Length of Card	Mean Effective Pressure	M.E.P. Corrected	Explosions per Minute	R.P.M.	I.H.P.	B.H.P.	Mech. Efficiency
1	1.55	3.47	71.5						
2	1.59	3.46	73.5						
3	1.58	3.46	73.1						
4	1.55	3.46	71.6						
5	1.53	3.45	71.0						
6	1.55	3.47	71.5						
Average			72.03	74.1	113.65	254.83	9.07	7.34	80.9

REMARKS:- SHIMS 0.0 INCHES THICK - COMPRESSION 57.5 POUNDS - BAROMETER - 29.47 INCHES.

SCALE SPRING - 160 POUNDS.

APRIL 27, 1909.



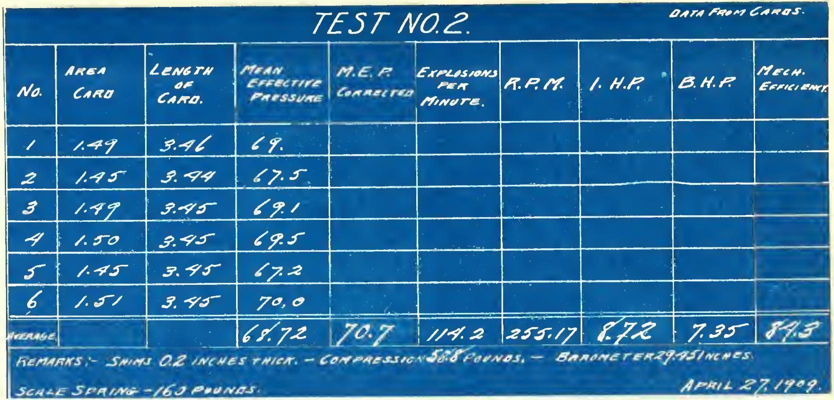
TEST NO. 2.

RUNNING LOG.

TIME	EXPLOSION COUNTER.	EXPLOSIONS PER MINUTE	REVOLUTIONS PER MINUTE	GAS METER READING.	CUBIC FEET GAS PER HOUR.	TEMPERATURE-DEGREES F. EMERGING JACKET WATER	ISSUING JACKET WATER.	GAS AT METER.	PRESSURE GAS AT METER INCHES WATER.	WEIGHT JACKET WATER POUNDS.	BRAKE SCALE READING POUNDS	BRAKE LOAD NET POUNDS.	BRAKE HORSE POWER.
2:45	64898		255	789.9		46	140	78	4.8	TARE 505			
2:55	66055		254	812.8		45	150.5	79	4.8				
3:05	67213		256	835.3		45	158.	79.5	4.8				
3:15	68364		256	858.1		46	156.5	78.5	4.8				
3:25	69403		254	880.8		45	151.	78.	4.8				
3:35	70640		256	903.5		44	162.5	77	4.8				
3:45	71750			926.5						FULL 893			
AVERAGE		114.2	255.17		196.6	45.17	153.08	78.33	4.8	388	82.5	71	7.35

REMARKS:- SHIMS 0.2 INCHES THICK. - COMPRESSION 58.8 POUNDS. - BAROMETER 29.45 INCHES.
POUNDING-NONE.

APRIL 27, 1909.



TEST NO. 2.

DATA FROM CARDS.

No.	AREA CARD	LENGTH OF CARD.	MEAN EFFECTIVE PRESSURE	M.E.P. CORRECTED	EXPLOSIONS PER MINUTE.	R.P.M.	I.H.P.	B.H.P.	MECH. EFFICIENCY.
1	1.49	3.46	69.						
2	1.45	3.44	67.5						
3	1.49	3.45	69.1						
4	1.50	3.45	69.5						
5	1.45	3.45	67.2						
6	1.51	3.45	70,0						
AVERAGE.			68.72	70.7	114.2	255.17	8.72	7.35	84.3

REMARKS:- SHIMS 0.2 INCHES THICK. - COMPRESSION 58.8 POUNDS. - BAROMETER 29.45 INCHES.

SCALE SPRING - 160 POUNDS.

APRIL 27. 1909.

TEST NO. 3.

RUNNING LOG.

TIME	EXPLOSION COUNTER.	EXPLOSIONS PER MINUTE.	REVOLUTIONS PER MINUTE.	GAS METER READING.	CUBIC FEET GAS PER HOUR.	TEMPERATURE-DEGREES F.			PRESSURE GAS AT METER INCHES WATER.	WEIGHT JACKET WATER POUNDS.	BRAKE SCALE READING POUNDS.	BRAKE LOAD NET. POUNDS.	BRAKE HORSE POWER.
						ENTERING JACKET WATER	ISSUING JACKET WATER	GAS AT METER.					
1:20	56770		256	624.4		45	147	75.5	4.2	TARE 506			
:30	57802		256	648.0		45	150	78.	4.2				
:40	59025		256	670.6		44.5	159	79	4.3				
:50	60152		255	693.5		45	145	80	4.4				
2:00	61288		257	716.7		45.5	156	80	4.4				
:10	62439		256	740.3		45	157	80.5	4.9				
:20	63595			763.6						FULL 929			
AVERAGE		113.75	256		139.2	45	152.66	78.833	4.4	423	82.5	71	7.37

REMARKS:— SHIMS 0.4 INCHES THICK — COMPRESSION 62.4 POUNDS — BAROMETER 29.41 INCHES.
POUNDING JUST NOTICABLE.

APRIL 27, 1909

[illegible]
INSTITUTE OF TECHNOLOGY
LIBRARY,

TEST NO. 3.

DATA FROM CARDS

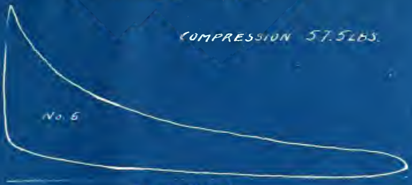
No.	AREA CARD	LENGTH OF CARD.	MEAN EFFECTIVE PRESSURE	M.E.P CORRECTED.	EXPLOSIONS PER MINUTE	R. P. M.	I. H. P.	B.H.P.	MECH. EFFICIENCY
1	1.40	3.43	65.3						
2	1.41	3.43	65.8						
3	1.45	3.43	67.6						
4	1.40	3.42	65.5						
5	1.45	3.43	67.6						
6	1.45	3.44	67.4						
AVERAGE			66.53	68.4	113.75	256.	8.39	7.37	87.9

REMARKS:– SHIMS – 0.4 INCHES THICK. – COMPRESSION – 62.4 POUNDS – BAROMETER 29.41 INCHES.

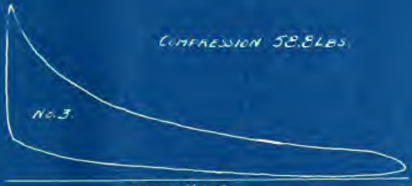
SCALE SPRING – 160 POUNDS.

APRIL 27, 1909.

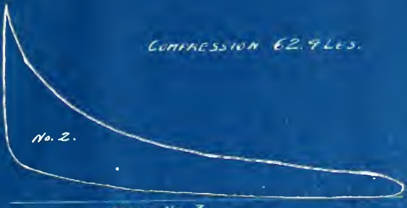
SAMPLE CARDS



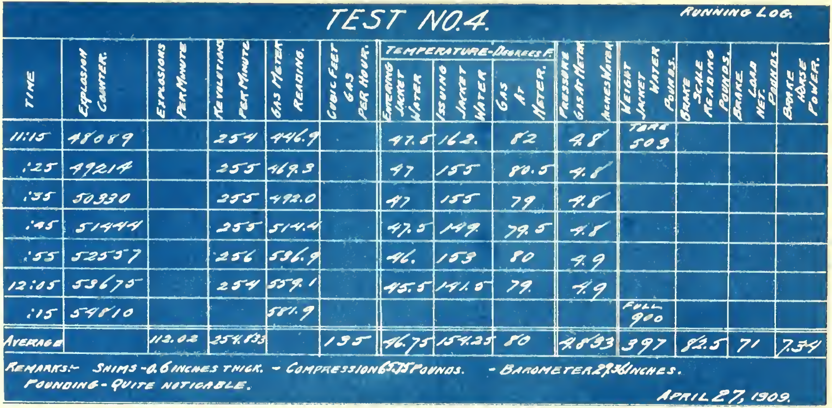
TEST NO. 1.



TEST NO. 2.



TEST NO. 3.



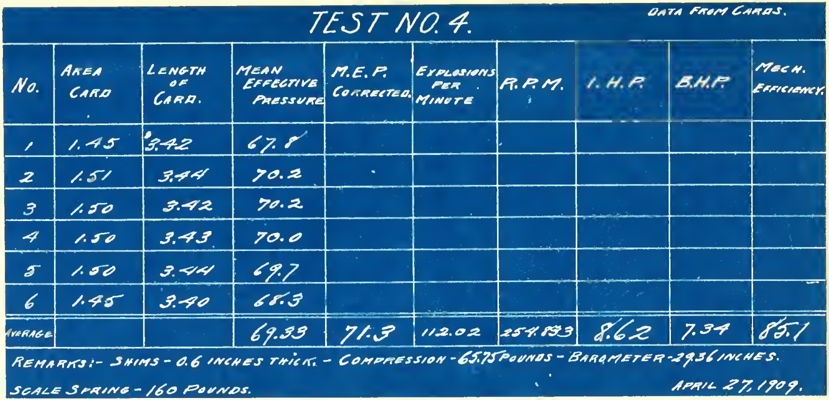
TEST NO.4.

RUNNING LOG.

TIME	EXPLOSION COUNTER.	EXPLOSIONS PER MINUTE	REVOLUTIONS PER MINUTE	GAS METER READING.	CUBIC FEET GAS PER HOUR.	TEMPERATURE-DEGREES F. ENTERING JACKET WATER	TEMPERATURE-DEGREES F. ISSUING JACKET WATER	TEMPERATURE-DEGREES F. GAS AT METER.	PRESSURE GAS AT METER INCHES WATER	WEIGHT JACKET WATER POUNDS.	BRAKE SCALE READING POUNDS.	BRAKE LOAD NET. POUNDS	BRAKE HORSE POWER.
11:15	48089		254	446.9		47.5	162.	82	4.8	TARE 503			
:25	49214		255	469.3		47	155	80.5	4.8				
:35	50330		255	492.0		47	155	79	4.8				
:45	51444		255	514.4		47.5	149.	79.5	4.8				
:55	52557		256	536.9		46.	153	80	4.9				
12:05	53675		254	559.1		45.5	141.5	79.	4.9				
:15	54810			581.9						FULL 900			
AVERAGE		112.02	254.833		135	46.75	154.25	80	4.833	397	82.5	71	7.54

REMARKS:- SHIMS - 0.6 INCHES THICK. - COMPRESSION 65.75 POUNDS. - BAROMETER 29.36 INCHES.
POUNDING - QUITE NOTICABLE.

APRIL 27, 1909.



TEST NO. 4.

DATA FROM CARDS.

No.	AREA CARD	LENGTH OF CARD.	MEAN EFFECTIVE PRESSURE	M.E.P. CORRECTED.	EXPLOSIONS PER MINUTE	R.P.M.	I.H.P.	B.H.P.	MECH. EFFICIENCY.
1	1.45	3.42	67.8						
2	1.51	3.44	70.2						
3	1.50	3.42	70.2						
4	1.50	3.43	70.0						
5	1.50	3.44	69.7						
6	1.45	3.40	68.3						
AVERAGE			69.33	71.3	112.02	254.833	8.62	7.34	85.1

REMARKS:- SHIMS - 0.6 INCHES THICK. - COMPRESSION - 65.75 POUNDS - BAROMETER - 29.36 INCHES.

SCALE SPRING - 160 POUNDS.

APRIL 27, 1909.

TEST NO. 5.

RUNNING LOG.

TIME	EXPLOSION COUNTER.	EXPLOSIONS PER MINUTE	REVOLUTIONS PER MINUTE	GAS METER READING.	CUBIC FEET GAS PER HOUR.	TEMPERATURE-DEGREES F.			PRESSURE GAS AT METER INCHES WATER	WEIGHT JACKET WATER POUNDS.	BRAKE SCALE READING POUNDS.	BRAKE LOAD NET POUNDS.	BRAKE HORSE POWER.
						ENTERING JACKET WATER.	ISSUING JACKET WATER	GAS AT METER.					
2:45	38722		255	262.8		47	167.5	81	4.8	TARE 580			
:55	39808		253	284.7		46	136.5	81.5	4.8				
3:05	40978		255	306.8		47.5	157.5	82	4.6				
:15	42110		254	328.8		47.	148.	81	4.6				
:25	43247		255	351.1		47.5	154.5	81	4.6				
:35	44386		256	373.2		47	153	80	4.6				
:45	45408			396.0						FULL 972			
AVERAGE		111.433	254.66		139.2	47	152.83	81.083	4.633	392	82.5	71	7.34

REMARKS:- SHIMS 0.8 INCHES THICK - COMPRESSION 70.8 POUNDS - BAROMETER - 27.47 INCHES.
POUNDING - SLIGHTLY LOUDER THAN TEST No. 4.

APRIL 26, 1909.

TEST NO. 5.

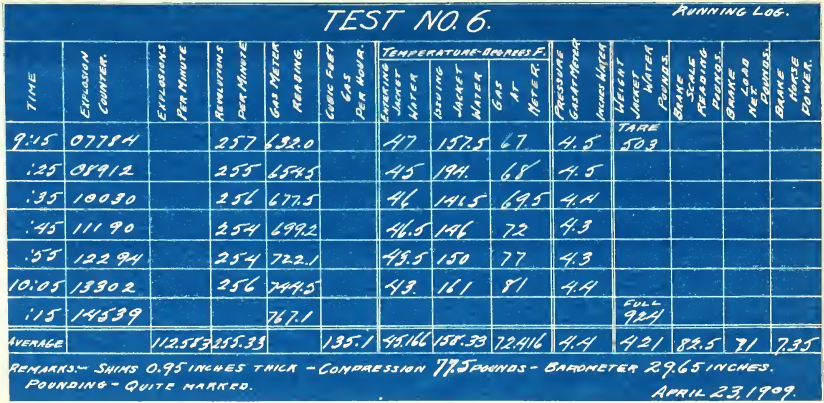
DATA FROM CARDS.

No.	AREA CARD	LENGTH OF CARD.	MEAN EFFECTIVE PRESSURE	M.E.P. CORRECTED	EXPLOSIONS PER MINUTE	R.P.M.	I.H.P.	B.H.P.	MECH. EFFICIENCY
1	1.55	3.42	72.5						
2	1.52	3.42	71.1						
3	1.49	3.42	69.8						
4	1.50	3.42	70.1						
5	1.50	3.41	70.4						
6	1.50.	3.42	70.1						
AVERAGE			70.66	72.6	111.433	254.66	8.73	7.34	84.0

REMARKS:- SHIMS - 0.8 INCHES THICK. - COMPRESSION - 70.8 POUNDS - BAROMETER 29.47 INCHES.

SCALE SPRING - 160 POUNDS.

APRIL 26, 1909



TEST NO. 6.

RUNNING LOG.

Time	Explosion Counter.	Explosions Per Minute	Revolutions Per Minute	Gas Meter Reading.	Cubic Feet Gas Per Hour.	Temperature-Degrees F. Entering Jacket Water	Temperature-Degrees F. Issuing Jacket Water	Temperature-Degrees F. Gas at Meter.	Pressure Gas at Meter Inches Water	Weight Jacket Water Pounds.	Brake Scale Reading Pounds.	Brake Load Net. Pounds.	Brake Horse Power.
9:15	07784		257	632.0		47	157.5	67	4.5	TARE 503			
:25	08912		255	654.5		45	194.	68	4.5				
:35	10030		256	677.5		46	141.5	69.5	4.4				
:45	111 90		254	699.2		46.5	146	72	4.3				
:55	122 94		254	722.1		45.5	150	77	4.3				
10:05	13302		256	744.5		43.	161	81	4.4				
:15	14539			767.1						FULL 924			
AVERAGE		112.583	255.33		135.1	45.166	158.33	72.416	4.4	421	82.5	71	7.35

REMARKS:— SHIMS 0.95 INCHES THICK — COMPRESSION 77.5 POUNDS — BAROMETER 29.65 INCHES.
POUNDING — QUITE MARKED.

APRIL 23, 1909.

CARNEGIE
INSTITUTE OF TECHNOLOGY
LIBRARY

TEST NO. 6.

DATA FROM CARDS.

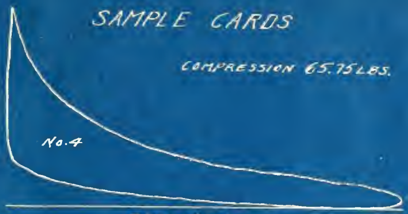
No.	AREA CARD	LENGTH OF CARD	MEAN EFFECTIVE PRESSURE	M.E.P. CORRECTED	EXPLOSIONS PER MINUTE	R.P.M.	I. H.P.	B.H.P.	MECH. EFFICIENCY.
1	1.50	3.38	71.0						
2	1.50	3.37	71.3						
3	1.49	3.35	71.2						
4	1.50	3.38	71.0						
5	1.50	3.38	71.0						
6	1.49	3.38	70.5						
AVERAGE			71.0	73.1	112.583	255.33	8.88	7.35	82.8

REMARKS:- SHIMS .95 INCHES THICK - COMPRESSION - 77.5 POUNDS - BAROMETER 29.65 INCHES.

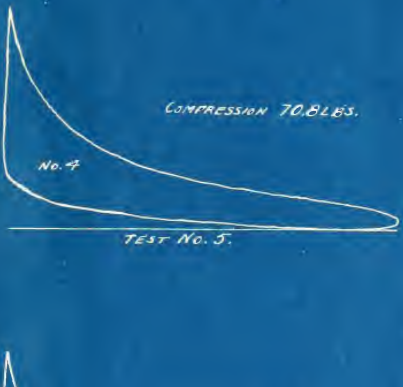
SCALE SPRING - 160 POUNDS

APRIL 23, 1909.

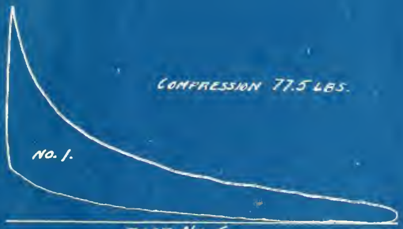
SAMPLE CARDS



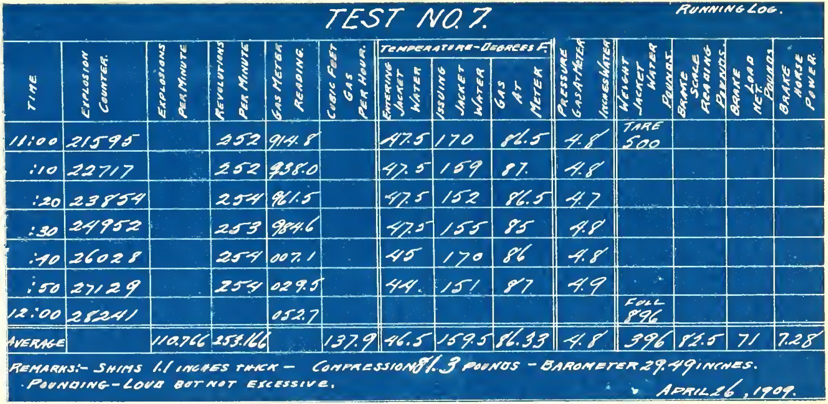
TEST No. 4.



TEST No. 5.



TEST No. 6.



TEST NO. 7.

RUNNING LOG.

TIME	EXPLOSION COUNTER.	EXPLOSIONS PER MINUTE	REVOLUTIONS PER MINUTE	GAS METER READING.	CUBIC FEET GAS PER HOUR.	TEMPERATURE - DEGREES F. ENTERING JACKET WATER	ISSUING JACKET WATER	GAS AT METER	PRESSURE GAS AT METER INCHES WATER	WEIGHT JACKET WATER POUNDS.	BRAKE SCALE READING POUNDS.	BRAKE LOAD NET. POUNDS	BRAKE HORSE POWER.
11:00	21595		252	914.8		47.5	170	86.5	4.8	TARE 500			
:10	22717		252	938.0		47.5	159	87.	4.8				
:20	23854		254	961.5		47.5	152	86.5	4.7				
:30	24952		253	984.6		47.5	155	85	4.8				
:40	26028		254	007.1		45	170	86	4.8				
:50	27129		254	029.5		44.	151	87	4.9				
12:00	28241			052.7						FULL 896			
AVERAGE		110.766	253.166		137.9	46.5	159.5	86.33	4.8	396	82.5	71	7.28

REMARKS:- SHIMS 1.1 INCHES THICK - COMPRESSION 81.3 POUNDS - BAROMETER 29.49 INCHES.
POUNDING - LOUD BUT NOT EXCESSIVE.

APRIL 26, 1909.

TEST NO. 7.

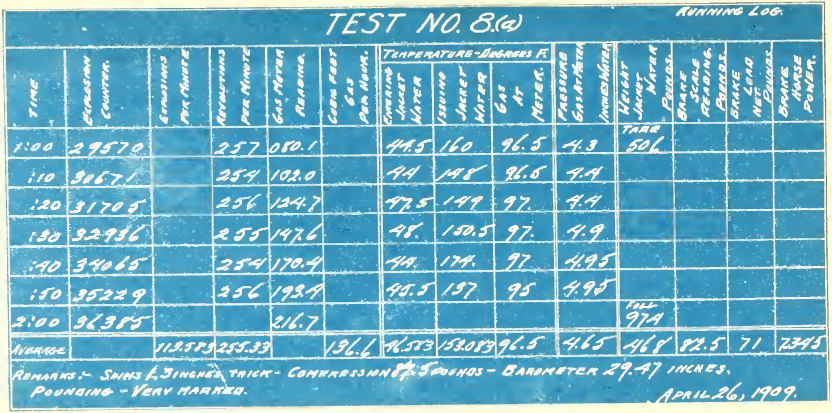
DATA FROM CARDS.

No.	AREA CARD	LENGTH OF CARD.	MEAN EFFECTIVE PRESSURE	M.E.P. CORRECTED	EXPLOSIONS PER MINUTE	R.P.M.	I.H.P.	B.H.P.	MECH. EFFICIENCY.
1	1.09	3.43	76.3						
2	1.01	3.42	70.9						
3	1.05	3.42	73.7						
4	1.05	3.42	73.6						
5	1.01	3.42	70.9						
6	1.09	3.42	76.5						
AVERAGE			73.65	76.7	110.766	253.17	9.16	7.28	79.5

REMARKS:– SHIMS - 1.1 INCHES THICK. – COMPRESSION-81.3 POUNDS - BAROMETER 29.49 INCHES

SCALE SPRING - 240 POUNDS.

APRIL 26, 1909.



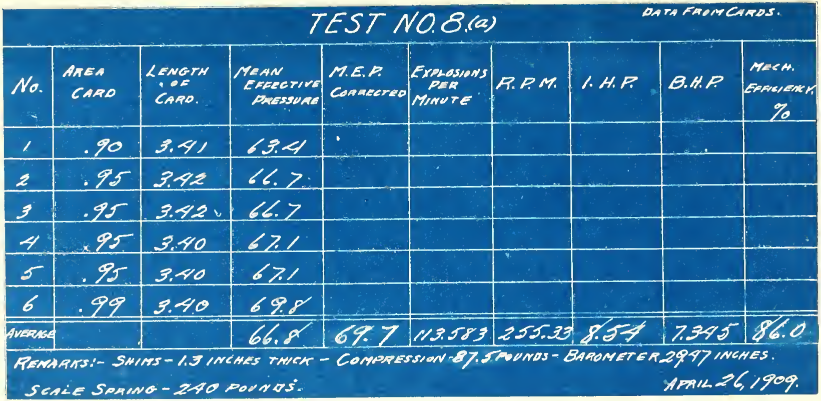
TEST NO. 8(a)

RUNNING LOG.

TIME	EXPLOSION COUNTER.	EXPLOSIONS PER MINUTE	REVOLUTIONS PER MINUTE	GAS METER READING.	CUBIC FEET GAS PER HOUR.	TEMPERATURE—DEGREES F. ENTERING JACKET WATER	ISSUING JACKET WATER	GAS AT METER.	PRESSURE GAS AT METER INCHES WATER	WEIGHT JACKET WATER POUNDS.	BRAKE SCALE READING. POUNDS.	BRAKE LOAD NET. POUNDS.	BRAKE HORSE POWER.
1:00	29570		257	080.1		44.5	160	96.5	4.3	TARE 506			
:10	30671		254	102.0		44	148	96.5	4.4				
:20	31705		256	124.7		47.5	149	97.	4.4				
:30	32936		255	147.6		48.	150.5	97.	4.9				
:40	34065		254	170.4		44.	174.	97	4.95				
:50	35229		256	193.4		45.5	137	95	4.95				
2:00	36385			216.7						FULL 974			
AVERAGE		113.583	255.33		136.6	46.583	153.083	96.5	4.65	468	82.5	71	7.345

REMARKS:— SHIMS 1.3 INCHES THICK — COMPRESSION 87.5 POUNDS — BAROMETER 29.47 INCHES.
POUNDING — VERY MARKED.

APRIL 26, 1909.



TEST NO. 8.(a)

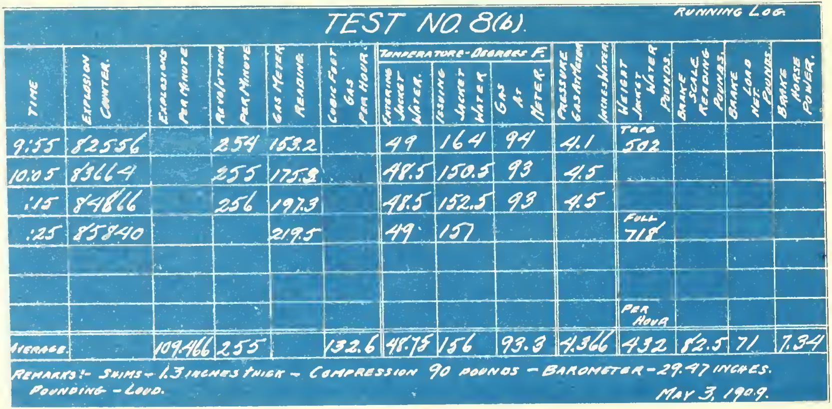
DATA FROM CARDS.

No.	AREA CARD	LENGTH OF CARD.	MEAN EFFECTIVE PRESSURE	M.E.P. CORRECTED	EXPLOSIONS PER MINUTE	R.P.M.	I.H.P.	B.H.P.	MECH. EFFICIENCY. %
1	.90	3.41	63.4						
2	.95	3.42	66.7						
3	.95	3.42	66.7						
4	.95	3.40	67.1						
5	.95	3.40	67.1						
6	.99	3.40	69.8						
AVERAGE			66.8	69.7	113.583	255.33	8.54	7.345	86.0

REMARKS:- SHIMS - 1.3 INCHES THICK - COMPRESSION - 87.5 POUNDS - BAROMETER 29.47 INCHES.

SCALE SPRING - 240 POUNDS.

APRIL 26, 1909.



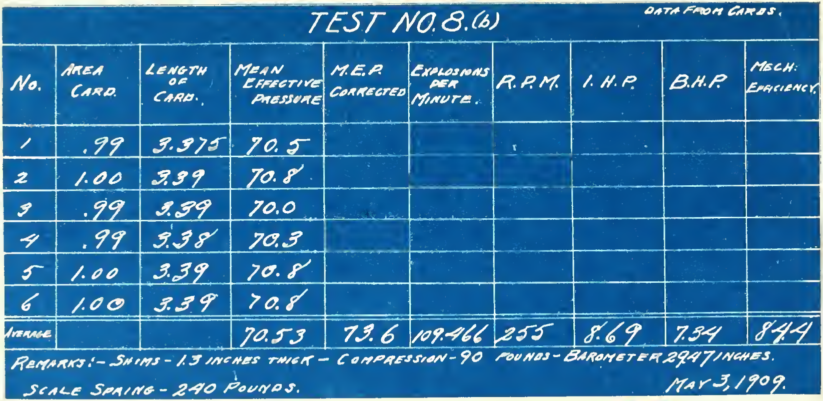
TEST NO. 8(b).

RUNNING LOG.

TIME	EXPLOSION COUNTER.	EXPLOSIONS PER MINUTE	REVOLUTIONS PER MINUTE	GAS METER READING.	CUBIC FEET GAS PER HOUR.	TEMPERATURE-DEGREES F. ENTERING JACKET WATER.	ISSUING JACKET WATER	GAS AT METER.	PRESSURE GAS AT METER INCHES WATER.	WEIGHT JACKET WATER POUNDS.	BRAKE SCALE READING POUNDS.	BRAKE LOAD NET. POUNDS.	BRAKE HORSE POWER.
9:55	82556		254	153.2		49	164	94	4.1	TARE 502			
10.05	83664		255	175.3		48.5	150.5	93	4.5				
:15	84866		256	197.3		48.5	152.5	93	4.5				
:25	85840			219.5		49	157			FULL 718			
										PER HOUR			
AVERAGE.		109.466	255		132.6	48.75	156	93.3	4.366	432	52.5	71	7.34

REMARKS:- SHIMS - 1.3 INCHES THICK - COMPRESSION 90 POUNDS - BAROMETER - 29.47 INCHES.
POUNDING - LOUD.

MAY 3, 1909.



TEST NO. 8. (b)

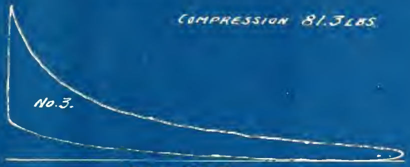
DATA FROM CARDS.

No.	AREA CARD.	LENGTH OF CARD.	MEAN EFFECTIVE PRESSURE	M.E.P. CORRECTED	EXPLOSIONS PER MINUTE.	R.P.M.	I. H.P.	B.H.P.	MECH: EFFICIENCY.
1	.99	3.375	70.5						
2	1.00	3.39	70.8						
3	.99	3.39	70.0						
4	.99	3.38	70.3						
5	1.00	3.39	70.8						
6	1.00	3.39	70.8						
AVERAGE			70.53	73.6	109.466	255	8.69	7.34	84.4

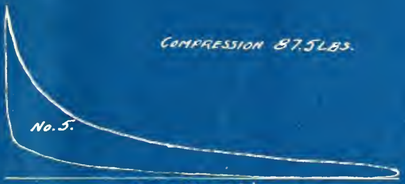
REMARKS:- SHIMS - 1.3 INCHES THICK - COMPRESSION - 90 POUNDS - BAROMETER 29.47 INCHES.
SCALE SPRING - 240 POUNDS.

MAY 3, 1909.

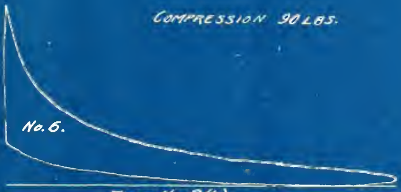
SAMPLE CARDS.



TEST No. 7.

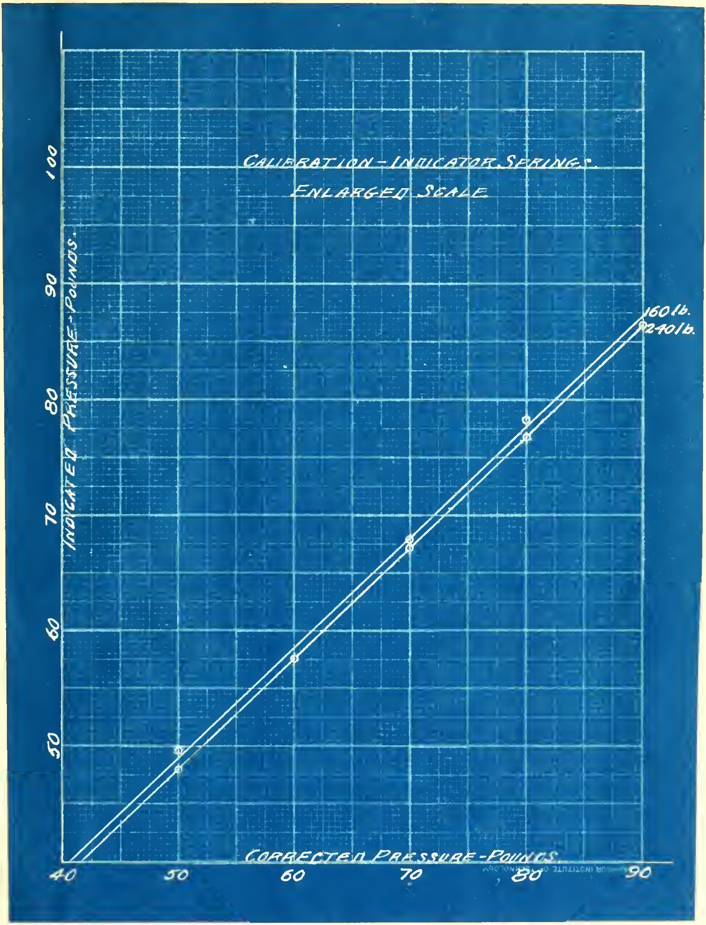


TEST No. 8 (a).



TEST No. 8 (b).

ARMOUR
INSTITUTE OF TECHNOLOGY
[illegible]


CALIBRATION - INDICATOR SPRINGS.
ENLARGED SCALE
INDICATED PRESSURE - POUNDS.
100
90
80
70
60
50
CORRECTED PRESSURE - POUNDS.
40
50
60
70
80
90
160 lb.
240 lb.

ARMOUR
INSTITUTE OF TECHNOLOGY
[illegible]